EXAMINATION OF THE TRANSFER OF DUST CONTAMINATED WITH POLYCHLORODIBENZO-P-DIOXINS AND POLYCHLORODIBENZOFURANS FROM THE LOFT INTO THE APARTMENTS BELOW

UNTERSUCHUNG DES TRANSFERS VON POLYCHLORIERTEN DIBENZO-P-DIOXINEN UND POLYCHLORIERTEN DIBENZOFURANEN AUS DACHBODENSTAUB IN DIE DARUNTERLIEGENDEN WOHNUNGEN

EXAMEN DU TRANSFERT DE POUSSIERES CONTAMINEES PAR DES POLYCHLORODIBENZO - P -DIOXINES ET DES POLYCHLORODIBENZO-FURANES DU GRENIER DANS LES APPARTEMENTS SITUES EN DESSOUS

Dagmar Hansen

SUMMARY

In our study we examined the transfer of dust contaminated with polychlorodibenzo-p-dioxins (dioxins) and polychlorodibenzofurans (furans) from the loft into the apartments of the same house. A factory near to that house had emitted dioxins and furans over years. At the time of the study the factory had been dismantled, everything had been restored.

The result showed a very high contamination of the attic dust. In comparison, the contamination of the apartment dust was 1000 times lower. The distribution of congeners in both types of dust is very similar and it seems that they come from the same source.

In comparison, the indoor air shows a higher concentration of dioxins and furans as the outdoor air, but has a normal concentration for air in the city. This means that the concentration of dioxins and furans measured in the indoor air is not unusually high.

The distribution of congeners in the air inside and outside is also very similar, and it is similar to the distribution in the dust.

Tendentious dioxins and furans are adsorbed at particles. Small particles will be whirled up more easily than big ones. We wanted to examine which particle size is more contaminated with dioxins and furans. Therefore we fractionated the attic dust in different particle sizes. Once we fractionated the attic dust directly in the loft, the other time we fractionated it in our laboratory.

There was no significant difference of dioxin and furan concentrations in the different particle sizes. This means that the particle size is not a determining factor. But there was a difference in the concentrations measured in the loft and those measured in the laboratory, the total concentration at the loft was significantly lower. This difference is based upon different dust weights. In the loft no dust had been whirled up. In the laboratory the dust had been whirled up permanently. In this case, heavy particles have been fractionated too. Through water sedimentation the attic dust was split up into a light and a heavy part. The heavy part contained mineral elements, the light part organic elements. The examination showed a higher concentration of dioxin and furan in the heavy part.

In another experiment we proved the vaporization behaviour of dioxins and furans at a high temperature (60°C), because in the loft higher temperatures are possible in summer time. The transfer was low and the pattern of the congeners was different from the pattern measured in the dust and in the air. Therefore the transfer is not significant.

The distribution of the characteristic leading congeners is comparable between attic dust, apartment dust, indoor and outdoor air. Therefore a definitive statement on the transfer of contaminated attic dust is not possible. Yet it can be established that, in case of a relevant transfer of the highly contaminated attic dust, a far higher contamination of the apartment dust could be expected.

ZUSAMMENFASSUNG

In der hier vorliegenden Studie wurde der Transfer eines mit polychlorierten Dibenzo-p-dioxinen (Dioxinen) und polychlorierten Dibenzofuranen (Furanen) belasteten Dachbodenstaubes in die darunterliegenden Wohnungen untersucht. Die Belastung des Dachbodenstaubes stammt aus einer jahrelangen Deposition dioxin- und furanhaltiger Staubpartikel von einem nahe gelegenen Emittenten. Dieser Emittent war zum Zeitpunkt der Studie schon seit einiger Zeit saniert.

Die Untersuchung des Dachbodenstaubes ergab, daß dieser sehr hoch mit Dioxinen und Furanen kontaminiert war.

Die Hausstaubproben in den darunterliegenden Wohnungen waren im Vergleich zum Dachbodenstaub um den Faktor 1000 geringer belastet, wobei

aufgrund einer im wesentlichen ähnlichen Kongenerenverteilung auf eine gleiche Quelle geschlossen werden kann.

Die Innenraumluftmessungen weisen zwar im Vergleich zur Aussenluft höhere Gehalte an Dioxinen und Furanen auf, aber sie befinden sich in den für Städte typischen Bereichen und stellen damit keine außergewöhnliche Belastung dar. Die Kongenerenmuster der Außenluft und Innenraumluft sind vergleichbar und entsprechen dem Muster der Staubproben.

Um eine Aussage über das Transportverhalten partikelgebundener Dioxine und Furane zu machen, wurde der Staub in unterschiedliche Partikelgrößen fraktioniert. Diese Fraktionierung erfolgte einmal vor Ort und einmal im Laborversuch. Innerhalb der verschiedenen Partikelgrössen sind keine signifikanten Unterschiede der Gehalte an Dioxine und Furane nachweisbar, d.h. daß für eine eventuelle Kontamination die Partikelgrösse des Staubes nicht relevant ist. Insgesamt werden im Laborversuch jedoch bedeutend höhere Konzentrationen als im Versuch vor Ort gemessen. Beim Versuchsaufbau im Labor wurden auch schwere Staubanteile aufgewirbelt.

Der inhomogene Dachbodenstaub wurde durch Sedimentation mit Wasser in einen schweren und einen leichteren Anteil aufgetrennt. Der schwere Anteil enthielt hauptsächlich mineralische Bestandteile und der leichte vorwiegend organische Anteile. Bei dieser Untersuchung konnte festgestellt werden, daß die schweren Anteile des Staubes höher belastet waren, d.h. die Dioxine und Furane finden hier eine höhere Adsorptionsmöglichkeit.

Zur Simulation der im Sommer auf Dachböden auftretenden erhöhten Temperaturen wurde in einem Versuch die Ausgasung von Dioxinen und Furanen aus Staub bei 60°C bestimmt. Die Ausgasung war nur sehr gering, und es wurde ein im Vergleich zu den Staub- und Innenraumluftproben andersartiges Kongenerenmuster gefunden. Daraus kann geschlossen werden, daß aufgrund von Ausgasungen bei erhöhten Temperaturen kein signifikanter Transfer der Dioxine und Furane stattgefunden hat.

Da die Verteilung der belastungstypischen Leitkongeneren von Dachbodenstaub, Hausstaub, Innenraumluft und Aussenluft vergleichbar sind, ist eine endgültige Aussage über den Transfer des belasteten Dachbodenstaubes nicht möglich. Es kann jedoch festgestellt werden, daß bei einem relevanten Transfer des hoch belasteten Dachbodenstaubes eine bedeutend höhere Kontamination der Hausstaubproben zu erwarten wäre.

RESUME

Dans l’étude présente, le transfert de poussières contaminées avec des polychlorodibenzo-p-dioxines (dioxines) et des polychlorodibenzofuranes (furanes) du grenier dans les appartements de la même maison. Une usine située à proximité de cette maison avait émis, pendant des années, des dioxines et furanes. Lors de l'étude, l'usine avait été démontée, tout avait été assaini.

Les examens ont montré une contamination très élevée de la poussière du grenier. En comparaison, la contamination de la poussière d'appartement était 1000 fois moindre. La distribution des congénères dans les deux types de poussière était très similaire et il semble qu'elles proviennent de la même source.

En comparaison, l'air intérieur montre une concentration en dioxines et furanes plus élevée que l'air extérieur, mais cette concentration est normale pour l'air en ville, ce qui signifie que la concentration en dioxines et furanes mesurée à l’intérieur n'est pas inhabituellement élevée.

La distribution de congénères dans l'air intérieur et extérieur sont similaires et correspondent à la distribution de la poussière.

Afin d’analyser le transfert des dioxines et furanes adsorbées aux particules de poussière, celle-ci a été fractionnée selon la taille des particules. Le fractionnement a été effectué dans le grenier d’une part et en laboratoire d’autre part. Aucune différence significative de concentration en dioxines et furanes n’a été constatée entre les différentes tailles. Cela signifie que la dimension des particules n’est pas un facteur déterminant pour une éventuelle contamination. Par contre les concentrations mesurées en laboratoire étaient nettement plus élevées que celles du grenier. Lors de la préparation des expériences en laboratoire, des particules lourdes ont également été soulevées.

La poussière inhomogène du grenier a été fractionnée par sédimentation dans de l’eau en une partie lourde et une partie légère. La partie lourde contenait essentiellement des éléments minéraux, la partie légère des éléments organiques. L’analyse a révélé une contamination en dioxines et furanes plus élevée de la partie lourde.

Dans une autre expérience nous avons analysé le comportement de vaporisation des dioxines et furanes à une température élevée (60°C), afin de simuler les températures possibles dans le grenier en été. Le transfert était bas et la répartition des congénères était différente de celles mesurées dans la poussière et dans l'air. Cela signifie que la vaporisation à des températures élevées ne cause pas de transfert significatif de dioxines et furanes.

La distribution des congénères caractéristiques de la poussière du grenier, de la poussière des appartements, de l’air extérieur et intérieur étant similaire, une déclaration définitive sur le transfert de la poussière contaminée du grenier n'est pas possible. On peut cependant dire que, si un transfert significatif de la poussière hautement contaminée du grenier avait lieu, les concentrations dans la poussière des appartements serait nettement plus élevée.

KEYWORDS
dioxins, furans, contaminated dust, indoor air, fractionation of dust into different particle size, sedimentation of dust into light and heavy parts, vaporization behaviour at high temperature

1 INTRODUCTION

There are about 75 different known dioxins and 135 different furans. Between all these 210 possibilities a big difference with regard to toxicity is known. Hereof 17 congeners are particularly toxic, they have a chlorosubstitution in point 2,3,7,8. The most toxic congener is the 2,3,7,8-Tetrachloro Dibenzo-p-dioxin (2,3,7,8-TCDD).

In order to estimate the toxic risk, Toxicity Equivalency Factors (TEF) are defined (the terms of the International Toxicity Equivalency Factors I-TEF are often used). The substances are compared with the most toxic compound. To get the International Toxicity Equivalency (I-TEq), the concentration of each congener is multiplied by its International Toxicity Equivalency Factor (I-TEF). Adding the 17 I-TEF-corrected concentrations generates a single number, which is the International Toxicity Equivalency (I-TEq).

Many toxic compounds are produced by industry, in opposition to dioxins and furans. Dioxins and furans are undesired by-products of chemical and thermal operations. They may be produced at trace levels by any combustion source, i.e. municipal incinerators.

In the last years laws have come into force in the Federal Republic of Germany which have reduced the dioxin and furan emission.

In our examination the attic dust was contaminated with dioxins and furans by a factory. At the time of the study the factory had been dismantled, everything had been restored.

We studied the transfer of the contaminated attic dust into the apartments below.

In the house of our study there are apartments on the ground floor, on the 1st and 2nd floors, and a loft which was not in use.

2 SEQUENCE OF EXAMINATION

First we examined the contamination of the attic dust.
Next we tested the contamination of dust and air in the apartments.

Then we wanted to study whether the particle size influences the transfer of dioxins and furans.

We also examined the vaporization behaviour of dioxins and furans at high temperatures.

3 EXAMINATION OF DUST IN THE ATTIC AND IN THE APARTMENTS

The collection of the attic dust was undertaken adhering to recommendations from the following: „Beprobung von dioxin- und furanbelasteten Häusern der Bund/Länder-Arbeitsgruppe DIOXINE [Schriftenreihe UMWELTPOLITIK, 2. Bericht]“.

A special industrial vacuum-cleaner was used to collect poisonous dust. Dioxins and furans are adsorbed at particles > 2 mm. Therefore only these particles were analysed. The dust was spiked with stable isotopically labeled compounds (in this case $^{13}C_{12}$-dioxins anf $^{13}C_{12}$-furans) according to EPA-Method 1613A.

The dust was extracted with dichlormethane for about 20-24 hours and it was cleaned according to EPA-Method 1613A.

The quantity of dioxins and furans was realized by high resolution capillary column gas chromatography and high resolution mass spectrometry (HRGC/HRMS). The results are shown in table 1.

The apartment dust was collected by a normal vacuum-cleaner. The method of examination was the same as the method used for the attic dust. Table 1 shows the results of the apartment dust from the ground floor (GF), the 1st floor (1st F), the 2nd floor (2nd F) and of the attic dust (attic).

Table 1: apartment dust and attic dust in ng/kg

dioxins / furans		GF	1st F	2nd F	attic
2,3,7,8	TCDD	< 1	4	< 1	490
1,2,3,7,8	PeCDD	10	30	12	7690
1,2,3,4,7,8	HxCDD	25	19	10	5710
1,2,3,6,7,8	HxCDD	98	38	19	9140
1,2,3,7,8,9	HxCDD	50	28	12	7100
1,2,3,4,6,7,8	HpCDD	14129	777	180	56800
	OCDD	96401	5968	580	67250
2,3,7,8	TCDF	48	96	39	n.d.
1,2,3,7.8	PeCDF	79	103	29	32560
2,3,4,7,8	PeCDF	110	156	62	46830
1,2,3,4,7,8	HxCDF	220	324	133	112000
1,2,3,6,7,8	HxCDF	100	161	44	49540
1,2,3,7,8,9	HxCDF	303	180	87	70930
2,3,4,6,7,8	HxCDF	54	85	49	50270
1,2,3,4,6,7,8	HpCDF	800	881	376	201000
1,2,3,4,7,8,9	HpCDF	86	116	68	38590
	OCDF	1369	392	321	137000
ng I-TEq /kg		402	219	85	62715

n.d.: not determined

This examination shows that, although the attic dust is highly contaminated, the contamination of the dust in the apartments is very low.

In order to make a statement on the transfer of contaminated dust, a closer look at the congener pattern, which is typical for dioxin and furan sources, has to be taken.

In the case of our emitter, we have the following characteristic leading congeners: 1,2,3,4,7,8-HxCDF; 2,3,4,6,7,8-HxCDF and 1,2,3,4,6,7,8-HpCDF (bold in table 1).

The distributions of congener patterns of the attic dust and the apartment dust are comparable. But in the dust of the ground floor apartment the Heptachloro- and Octachlorodioxins (HpCDD, OCDD) dominate. This shows that a further dioxin source could be present. For example the wood preservative named Pentachlorophenol is responsible for high HpCDD- and OCDD-concentrations. [Schweinsberg, Zöltzer, Volland: 1993]

According to the „Bundesgesundheitsamt“, a contamination of apartment dust between 10 - 100 ng I-TEq/kg is common. In accordance with these values, the dust of the ground floor apartment and the 1st floor apartment are contaminated, whereas the dust of the 2nd floor apartment shows only normal pollution. In the ground floor dust, HpCDD and OCDD are responsible for the high values of the International Toxicity Equivalency (I-TEq).

Table 2 shows the values of International Toxicity Equivalency Factors I-TEF and the product of I-TEF with the concentration of the congeners (I-TEq) for each type of apartment dust.

4 EXAMINATION OF THE INDOOR AIR

We wanted to see whether the indoor air was contaminated. Following „VDI-Richtlinie 3498“ [1993], the dust floating in the air was collected over 14 days. The air was absorbed through a ORBO-1000 Cartridge (Fa. SUPELCO) with a rate of 2 l/min. The adsorbent in the ORBO-1000 Cartridge is a polyurethan-foam (PUF), which is specially produced for air measurement. The PUF has been spiked with stable isotopically labeled dioxins and furans. The analysis

was equal to the analysis of the dust. Table 3 shows the results of the indoor air and of the outdoor air (O1 and O2).

Table 2: I-TE - values for apartment dust in ng/kg

dioxins / furans		I-TEF	GF	1st F	2nd F
2,3,7,8	TCDD	1	< 1	4	< 1
1,2,3,7,8	PeCDD	0.5	5	15	6
1,2,3,4,7,8	HxCDD	0.1	2.5	1.9	1
1,2,3,6,7,8	HxCDD	0.1	9.8	3.8	1.9
1,2,3,7,8,9	HxCDD	0.1	5.0	2.8	1.2
1,2,3,4,6,7,8	HpCDD	0.01	141.29	7.77	1.8
	OCDD	0.001	96.401	5.968	0.58
2,3,7,8	TCDF	0.1	4.8	9.6	3.9
1,2,3,7.8	PeCDF	0.05	3.95	5.15	1.45
2,3,4,7,8	PeCDF	0.5	55	78	31
1,2,3,4,7,8	HxCDF	0.1	22	32.4	13.3
1,2,3,6,7,8	HxCDF	0.1	10	16.1	4.4
1,2,3,7,8,9	HxCDF	0.1	30.3	18	8.7
2,3,4,6,7,8	HxCDF	0.1	5.4	8.5	4.9
1,2,3,4,6,7,8	HpCDF	0.01	8	8.81	3.76
1,2,3,4,7,8,9	HpCDF	0.01	0.86	1.16	0.68
	OCDF	0.001	1.369	0.392	0.321
ng I-TEq /kg			402	219	85

If we look at both indoor and outdoor air, we see that the values for the apartment indoor air are higher than the values for the outdoor air. The distribution of the congener pattern shows that in the air of the ground floor apartment HpCDD and OCDD are dominant, as they are dominant in the dust of the ground floor apartment (see table 1). This domination is, as in the ground floor dust, responsible for a high immission concentration. Table 4 shows characteristic immission-concentrations.

Table 3: concentrations of indoor and outdoor air in pg/m³

dioxins / furans		GF	1st F	2nd F	O1	O2
2,3,7,8	TCDD	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
1,2,3,7,8	PeCDD	0.02	< 0.01	0.03	< 0.01	0.01
1,2,3,4,7,8	HxCDD	0.01	0.01	0.02	0.01	0.03
1,2,3,6,7,8	HxCDD	0.02	0.02	0.03	0.01	0.02
1,2,3,7,8,9	HxCDD	0.01	0.01	0.01	< 0.01	0.01
1,2,3,4,6,7,8	HpCDD	3.97	0.1	0.05	0.09	0.12
	OCDD	25.12	0.72	0.29	0.16	0.24
2,3,7,8	TCDF	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
1,2,3,7.8	PeCDF	0.02	0.02	0.02	< 0.01	< 0.01
2,3,4,7,8	PeCDF	0.02	0.04	0.04	0.01	0.02
1,2,3,4,7,8	HxCDF	0.06	0.08	0.08	0.03	0.04
1,2,3,6,7,8	HxCDF	0.04	0.04	0.02	0.01	0.01
1,2,3,7,8,9	HxCDF	0.06	0.06	0.06	0.02	0.03
2,3,4,6,7,8	HxCDF	0.01	0.02	0.02	0.01	0.01
1,2,3,4,6,7,8	HpCDF	0.22	0.24	0.14	0.12	0.10
1,2,3,4,7,8,9	HpCDF	0.02	0.04	0.02	0.04	0.03
	OCDF	0.38	0.12	0.14	0.27	0.32
pg I-TEq /m³		0.11	0.05	0.06	0.02	0.03

Table 4: immission-concentrations

rural air	0.025 - 0.070	pg I-TEq /m³
city air	0.070 - 0.350	pg I-TEq /m³
air near by a emittent	0.350 - 1.600	pg I-TEq /m³

The indoor air of the 1st and 2nd floor apartments are comparable to rural air values. The indoor air value of the ground floor apartment is comparable to city air value.

A comparison made between indoor and outdoor congener patterns shows that they correlate with each other and with the dust congener pattern.

In this case it is not possible to state whether the pollution of indoor air is due to outdoor air or to the transfer of attic dust.

5 EXAMINATION OF THE FRACTIONATED ATTIC DUST

We have seen that the contamination of the attic dust was very high, whereas the contamination of indoor air and dust in the apartments below, especially the 2nd floor apartment, was low and corresponds to normal pollution. If we look at the congener pattern, we see that they are all very similar, though it could be possible that there has been a contamination by attic dust.

Tendentious dioxins and furans are absorbed at particles. Accordingly, transportation of dioxins and furans is possible by transportation of particles. A contamination of dioxins and furans must correlate with the transfer of dust particles. Dust particles can be whirled up more or less in accordance with specific size and specific weight. In order to evaluate how people were exposed to particles transported in the air, fractions of particle sizes are defined. [Siekmann, Blome; 1994]

The fractionation of the attic dust particles was carried out by a dust fraction-collector, which divided the particles into the following sizes: <3.5µm, <6µm, <10µm, <17µm, <30µm and inhalable. Once, the fractionating was carried out directly in the loft. The other time it was carried out in our laboratory. Here the dust had been whirled up permanently by nitrogen. In this case heavy particles had also been whirled up.

Table 5 shows the concentration of the leading congeners fractionated in the loft and table 6 shows the results from fractionation in the laboratory. Table 7 shows the values of the leading congeners from the attic dust which has not been fractionated (see also table 1).

Table 5: fractionating of attic dust in the loft [µg/kg]

leading congeners		<3.5µm	<6 µm	<10µm	<17µm	<30µm	inhalable
1,2,3,4,7,8	HxCDF	2	3	< 2	3	3	4
2,3,4,6,7,8	HxCDF	3	5	< 2	3	4	7
1,2,3,4,6,7,8	HpCDF	4	7	5	5	5	7

Table 6: fractionating of attic dust in the laboratory [µg/kg]

leading congeners		<3.5µm	<6 µm	<10µm	<17µm	<30µm	inhalable
1,2,3,4,7,8	HxCDF	180	180	191	193	121	155
2,3,4,6,7,8	HxCDF	123	131	129	131	90	120
1,2,3,4,6,7,8	HpCDF	499	509	493	472	340	426

Table 7: attic dust, not fractionated [µg/kg]

leading congeners		not fractionated
1,2,3,4,7,8	HxCDF	112
2,3,4,6,7,8	HxCDF	50
1,2,3,4,6,7,8	HpCDF	201

The experiment at the loft shows that there is no significant difference in the values of leading congeners among themselves and in all fractions, but these concentrations are much lower than those of the unfractionated attic dust. The experiment in the laboratory shows that the concentration of the leading congeners are similar, independent of particle size. These values are nearly the same as the values of the attic dust which has not been fractionated.

In the loft the dust had been collected continuously over 14 days. In the laboratory the dust had been permanently whirled up with nitrogen. In this case, heavy particles had also been whirled up and fractionated.

The fractionation of the attic dust shows that particle size is not a determining factor.

6 SEDIMENTATION OF THE ATTIC DUST WITH WATER

Attic dust is not very homogenous. It for example contains weather-beaten parts of the building, earthen parts or humus.

The attic dust of our research contained a lot of inorganic, silicate materials such as parts of tiles or cement. In this case dioxins and furans have different possibilities for adsorption. In order to find out which possibilities they preferred, we split the dust up into two fractions, a light fraction (specific weight $<1 g/m^3$) and a heavy fraction (specific weight $>1 g/m^3$). For sedimentation the dust was put into water and then mixed up very thoroughly. After sedimentation over night, the heavy part had completely settled on the ground; it was taken away the next day. The heavy part measured about 96%. The light fraction contained mainly organic parts, the heavy one mainly mineral parts. Table 8 shows the concentration of leading congeners in the light and heavy fraction and also of the unfractionated dust.

Table 8: sedimentation of attic dust [µg/kg]

leading congeners	light dust	heavy dust	unfractionated
1,2,3,4,7,8 HxCDF	24	125	112
2,3,4,6,7,8 HxCDF	19	94	50
1,2,3,4,6,7,8 HpCDF	58	322	201

In the heavy fraction, the concentration of the leading congeners is higher than in the light fraction. In the heavy fraction, there is a better potential for adsorption of dioxins and furans.

7 VAPORIZATION BEHAVIOUR OF DIOXINS AND FURANS AT 60°C

In summer time, high temperatures of up to 60°C are possible in the loft. For that reason, we wanted to analyse the vaporization behaviour of dioxins and furans.

In our laboratory the dust was heated up to 60°C over 4 weeks. The vapour produced was blown away with nitrogen and collected in a PUF- Car-

tridge. We compared the absolute values of the congeners which had been vaporized under these examination conditions with the absolute values of the congeners of the attic dust. Table 9 shows the result as a percentage.

Table 9: vaporization behaviour of dioxins and furans [%]

dioxins / furans		%
2,3,7,8	TCDD	0.57
1,2,3,7,8	PeCDD	0.10
1,2,3,4,7,8	HxCDD	0.05
1,2,3,6,7,8	HxCDD	0.07
1,2,3,7,8,9	HxCDD	0.04
1,2,3,4,6,7,8	HpCDD	< 0.02
	OCDD	< 0.02
2,3,7,8	TCDF	0.51
1,2,3,7.8	PeCDF	0.27
2,3,4,7,8	PeCDF	0.23
1,2,3,4,7,8	HxCDF	0.07
1,2,3,7,8,9	HxCDF	0.04
2,3,4,6,7,8	HxCDF	0.04
1,2,3,4,6,7,8	HpCDF	0.03
1,2,3,4,7,8,9	HpCDF	0.01
	OCDF	0.005

The vaporization of dioxins and furans increases with a decreasing chlorine rate. The congener pattern is completely different to the congener patterns measured in the different dusts and indoor airs.

No significant transfer of dioxins and furans by vaporization at high temperatures exist.

8 CONCLUSION

Our study shows that, although the attic dust is highly contaminated, the contamination of the dust in the apartments is very low.

The values of the indoor air is similar to values measured in cities and only corresponds to normal pollution.

Particle size is not a determining factor for contamination by transfer of attic dust.

Division of the dust into heavy and light parts shows that the heavy part is more highly contaminated.

The congener pattern of the vaporized dioxins and furans is completely different to the congener patterns measured in the different dusts and indoor airs.

It is not possible to make a statement about the transfer of contaminated attic dust, because the distributions of congeners of the attic dust, apartment dust, indoor and outdoor air are very similar.

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